Measuring the benefits of University Research:
Impact and the REF in the UK

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Abstract

The Research Excellence Framework (REF) is the latest attempt by the UK government to evaluate research in UK universities. A key component of this is the evaluation of the economic and societal impact of research. We discuss the nature of such impact and how, in an ideal world we would measure it. We then evaluate a number of REF case studies and conclude that they are a long way from being an accurate reflection of impact. They are primarily narratives, with little hard information and no attempt to discount over time or spatially, or to evaluate against a counterfactual. But the REF deserves credit for focusing attention on impact and it must be recognised that at this point in time, a first best methodology is not possible. Both the research councils and the universities need to begin collecting data which will facilitate improved analyses in the future.

Key words: University research, evaluation, research impact, REF

1. Introduction

The case can be made that in the 21st century innovation is of greater importance to the economy and society than at any previous time in our history. This is reflected in Obama's introduction to a document outlining America's strategy for innovation (Obama, 2011) in which he observes that, in part due to globalisation increasing competitiveness, "innovation is more important than ever" being the key to good, new jobs for the 21st century. But arguably the case is even stronger. In 2014 the world in general, and the EU in particular, still stands at risk of an economic downturn from which it may take several years to recover. On top of this we have problems of climate change, and food and resource shortages. Innovation is key to resolving these problems (Brander, 2010).

Universities play a key role in innovation. The benefits of university research are wide, highly influential and not restricted to innovation per se, particularly when this is narrowly defined. They include bringing new knowledge and perspectives to new and existing businesses and state agencies, introducing highly-skilled graduates equipped with the qualities crucial to having a cutting edge advantage over competitors, improving business strategies and productivity and contributing to policy formulation. Yet at a time when heavily indebted governments are seeking to reduce spending by any means possible, it is not sufficient to make such claims without providing supporting evidence. This is, in part, why in many countries, universities are being evaluated for their research strength, an evaluation which often is the basis for future funding. In the UK this has over the years been done through a form of peer review. This is not the only option and there is a substantial literature comparing the relative merits of expert panels and bibliometrics (Abramo *et al.*, 2013), although this discussion tends to be focused on measuring the quality of scientific publications. Indeed publications have tended to be the primary focus of such evaluations, although wider aspects such as the university's research environment are frequently taken into account (Nosengo, 2013). However, in the UK for the upcoming Research Excellence Framework[1] (REF), evidence of research impact on the economy and society is being introduced as a new component. This decision has been the subject of some discussion and criticism (Smith, et al., 2011) particularly revolving around the concept of academic autonomy.

Watermeyer (2014) encapsulates much of this criticism. Much of it is along the lines of curtailing academic freedom in the pursuit of knowledge freely available to all, and forcing academia, to work for the benefit of the wider society and economy of, in this case, the UK. However, there is also the claim that the process will not enhance impact per se, but merely change academics and universities behaviour in a way which will also have negative side effects. Academics will learn how to ‘play the game’, they will become experienced at ‘touting their wares’, in a process which will divert them from other activities including genuine research. The result may be that a highly homogenised and one-dimensional version of impact comes to dominate the REF submissions. The fear is also expressed that academics may become less radical due to a fear that it their work would be less likely to be taken up by others. It may also cause academics to focus on research with immediate potential impact rather than something more diffuse. It is also possibile that universities will reward, and base hiring strategies on the basis of impact, as a good impact case study is worth substantially more than a good 4* paper or book. All of this, it is suggested, may drive academics away from academia.

Despite these concerns, academics up and down the country have been busy constructing impact case studies. These focus on economic and societal impact, forcing many academics to come to grips with the problem of evaluating their own research in a somewhat unfamiliar way. There is much that is at stake in the REF. Firstly, the funding bodies will use the assessment outcomes to inform the selective allocation of their research funding to universities from 2015-

[1] The amount of literature on the REF itself is quite limited, but this is supplemented by a lot of information on various blogs, including by the London School of Economics and Political Science and by the British Medical Journal. See http://blogs.bmj.com/bmj/2013/05/07/richard-smith-the-irrationality-of-the-ref/ and

16 onwards[2]. Indeed it has been reported that a single case study could be worth as much as £720,000 to a University over a five year period (Dunleavy, 2012). But perhaps as important is the reputational impact. The REF outcomes will have an impact on the several rankings of universities in individual subjects which are an important factor in determining where students wish to study.

In this paper we will analyse the process of assessing economic impact as it relates to the REF. The analysis is focused on REF impact case studies to evaluate how successful the exercise will be in capturing impact. In doing this our analysis will also give insights into the problems of measuring such impact. Impact in many cases involves innovation[3], in the sciences often with a new product or process, and in other disciplines often involving policy innovation. Hence to understand impact we must first understand innovation. This is looked at in section 2. In section 3 we review the literature on impact evaluation and then building on this in section 4 we discuss how we would ideally measure total impact when it encompasses multiple impacts and both time and spatial discounting. This ideal is then contrasted with the approach taken in a set of case studies used to pilot the REF. Finally, we conclude the paper, with suggestions as to how the impact agenda should evolve. The analysis reveals potential problems with the REF, both in the way economic impact has been evaluated and in establishing the linkages between the underlying research and that economic impact, particularly for the non-sciences. Almost inevitably perhaps, the measures of impact cited in the case studies are somewhat weak, imprecise and incomplete. Indeed they are more narratives, rather than genuine attempts to provide measures of total impact. In the future, research funders and universities themselves will need to systematically collect information on impact, in all of its dimensions, for many years after the initial funding. Even then a 'first best' method of evaluating the impact of academic research may simply be out of our reach for some time. Nonetheless, in our view the REF has still performed a valuable function in raising the profile of impact. The case studies tell

[2] In 2014-15 HEFCE, the Higher Education Funding Council who organise the REF and fund the universities, plan to distribute £1.6 billion quality related research funding.

[3] In addition the innovation should be a useful innovation, which of course does not apply to all innovations. In addition, the ability to win grants from the research councils charities, the European Union and government departments for specific research projects are also likely to depend upon the outcome of the REF.

a story of strong and diverse impact, albeit one where much of the benefit accrues to foreign multinationals, economies and governments rather than to the UK.

2. Research, innovation and measuring impact

2.1 Innovation

The impact of academic research often involves innovation in some form and we cannot understand impact without first understanding innovation. The innovation may involve policy, but we initially focus on more traditional forms of innovation. Until the 1990s the linear model of innovation policy was dominant. This viewed technical change as happening in a linear fashion from invention to innovation to diffusion. The stages of the "Technology Push", version of the original linear model, are: Basic science→Design and engineering→ Manufacturing→ Marketing→ Sales. In this model the role of universities is often fundamental at the beginning of the process. However, in the past decade a new understanding of the nature of the innovation process has emerged, which emphasizes the systemic and interactive character of innovation (Todtling and Trippl, 2005). This approach argues that innovation should be seen as an evolutionary, non-linear and interactive process, requiring intensive communication and collaboration within companies and between firms and organisations such as universities, financial institutions and government agencies. An example of this is the triple helix model which emphasises interaction between university, industry and government (Etzkowitz and Leydesdorff, 2000) and a more system-centred approach of innovation policy (Nauwelaers and Wintjes, 2003) . This does not mean that focusing on R&D and on the technological aspects of innovation is the wrong policy, but that it needs to be complemented with the organisational, financial, skill and commercial aspects of innovation.

Whatever model of innovation we focus on it is apparent that research is not innovation. The active participation of an innovation partner, someone, whom in some contexts we would call ‘the entrepreneur’, is needed to successfully bring the innovation to market. Failure to do this means that the research, no matter how good will have very little impact. In many of the science case studies discussed below the entrepreneur was, at least in part, the academic themselves or others in their university, with a university spin-out company promoting the research and bringing it to the market or nearer to the market. However, these spin-out companies still often need outside assistance in the form of venture capitalists to provide them with much of their funding, and often they need the engagement of a larger firm to actually bring the product to the market.

The entrepreneur, or innovation partner, is critical to private sector innovation, but is equally so to public sector policies and practices, although the persona of the entrepreneur may be slightly different. In many cases the partner is a public sector agency, or their employees. Often, the initial impetus comes from the partner who commissions a piece of research often put out to public tender, which is substantially different to research funded by the research councils. In the former case the partner is likely to have been informed and influenced by previous research. In any case, the fundamental reality, even in the public sector, remains that without an innovation partner, direct impact is more likely to be restricted to contributions to the research commons filtering out to the non-academic community. Hence research may fail to have impact because it is not good research, better research elsewhere makes it obsolete, or because there is a failure further down the innovation track to exploit the research and bring it to market (Ekboir, 2003).

2.2 What is economic impact?

‘Outcome’ is often used to describe a mid-term and intermediate effect, and ‘impact’ a long-term and ultimate effect (CHSRF, 2008, White 2010). Impact typically refers to the final level of the causal chain after the project outcome. This definition of impact is also used by the Australian Technology Network (ATN, 2007). Engel-Cox et al. (2008) used a similar approach for developing a conceptual model for research metrics. In their model, impact is imbedded under the outcome umbrella as intermediate to long-term outcomes of the research. The problem with this is that often impact then relates to research done in the long distant past. Thus of necessity the evaluation of the contribution of research in the recent past must in part rely on outcome together with an extrapolation of outcome into likely impact. In what follows we will use the terms impact and outcome interchangeably, as indeed does the REF itself.

Wolff (2010) defines impact for academic research as “making a demonstrable difference in a non-academic context”. An economic impact exists when it affects the welfare of consumers, the profits of firms or the revenue of government(s). The economic impacts of science and innovation include the resulting contributions to long-term, sustainable economic growth (Romer, 1990) and increased overall welfare. The counterfactual is a critical concept. What would have been the scenario if the research did not exist, subtract that from the situation we have and that is research impact. The scope of economic impacts ranges from those easily quantifiable, in terms of greater wealth, cheaper prices and more revenue, to those less easily quantifiable in monetary terms, such as the effects on public health, the environment, or the quality of life (QOL).

3. The Literature

Traditionally, the success of academic research has been judged in quite narrow ways, usually by an assessment of peer-reviewed, published output through bibliometric analysis using citation tracking (Lindsey, 1989; Hicks, 1991). In Italy Abramo et al. (2013) compare the national research evaluation exercise and bibliometric measures, concluding that for the hard sciences the latter would have been satisfactory. This exercise was targeted primarily at publications, but as we saw in the previous section there has been a growing tendency in recent years to describe and analyze impact beyond this traditional academic framework. Reflecting this, several national research funders, such as the UK’s Medical Research Council and the Australian Research Council, have articulated analytical frameworks to identify the variables involved in impact assessment and the best metrics to capture them.

There is a tendency for researchers and research funders to overestimate, or at least overstate, the likely short- and medium-term impact of research, in their enthusiasm to justify its importance (Molas-Galant *et al*, 2002). In part this is possible because of the challenging nature of the task. The challenges arise for a number of reasons. Firstly, research can have direct as well as indirect economic effects. Moreover, as the world is becoming a small nexus of interconnecting research entities it is particularly difficult to attribute domestic economic impacts to only domestic research outcome. Yet if one is attempting to measure or evaluate the impact of the public funding of UK research this is exactly what we must seek to do. Thirdly the time lag between research undertaken and the realization of impact can be variable and often lengthy, and the longer the time lag the more difficult it becomes to trace the impact of the research. For example, a survey of corporate R&D executives showed that an average of 6 years elapsed between a research finding and commercialization (Mansfield, 1998). A cost-benefit analysis using this survey data showed a very high social rate of return resulting from academic research. The time lag affects the discounting process and using a shorter lag time in the discounting process would increase the benefit/cost ratio and the social rate of return (Kostoff, 1994).

The focus of the literature has been on measuring both the impact of specific projects and the impact of all research, or research funding. There are different methodologies that have been developed throughout the years to do these tasks. De Campos (2010) has divided these into three types of approach based on (i) case studies, (ii) surveys and (iii) quantitative approaches, with a particular focus on how they have been used by UK research councils in recent years. Quantitative approaches include ones based on econometrics, with an early example being that of Solow et al. (1958). The economic surplus approach pioneered by Griliches (1958) estimates the returns on investment, calculating the change in consumer and producer surpluses that result from technological change brought about through research. The estimated economic surpluses, together with research costs are then used to compute the net present value or internal rate of return. Another approach pioneered by Evenson and Pray (1991), employs a production function, cost function, or total factor productivity analysis to estimate the change in productivity due to research. This is then used to derive a marginal rate of return to research investment. A study to estimate the amount of output growth that can be attributed to technological development, led to the conclusion that it could be around 30 to 45% (Stoneman, 1987). This econometric approach may be the only way to get a holistic estimate of research impact, but it faces problems (Maredia et al., 2000), including those caused by a relative lack of data, the interconnected nature of research and the multiplicity of factors which can impact on the dependent variable. It is also based on identifying research induced structural breaks with the past. However, extrapolating from the past in this manner may not be a wholly satisfactory way of capturing the counterfactual, which in itself often involves a break with the past.

Attempts have also been made to use models that focus on the ‘return on investment’ or ‘research payback’ (Buxton and Hanney, 1996; Hanney et al., 2003; Wooding et al., 2004) which perhaps more closely resemble efforts at evaluating the impact of private sector investment than other measures of impact. Potential impacts were identified as: (i) knowledge production, (ii) research capacity building, (iii) policy or product development and (iv) wider societal benefits from increased population health or productivity. Assessments in each of these categories are derived from multiple data sources, including documentary evidence, surveys and interviews. The data so gathered are sometimes then scored in each category, Such approaches to impact assessment can then provide a profile of scores across each category and these data can be presented, for example in spider plots, to compare profiles of impacts across projects.

At the other end of the spectrum, there are studies based mostly on qualitative evidence (Yin, 2009). These tend to be focused on specific projects. Case studies offer a detailed view of how and why processes occur, and are useful in evaluating social, cultural, policy and practice impacts, although there is a danger they will focus on successful, rather than unsuccessful, research. Other qualitative methods include expert testimony, longitudinal historical studies, documentary analysis, sociological analysis, Delphi methods and logic models (Boaz et al. 2009; Georghiou et al., 2002; Valdez and Lane, 2008). Some studies have combined both qualitative and quantitative measures to capture a more thorough analysis of impact. Survey questionnaires can also underpin the compilation of data for policy impacts (Boaz et al., 2009). and were used in Salter and Martin’s (2001) exploration of the different channels the benefits from basic research can take.

A study prepared for the ESRC by Molas-Gallart *et al.* (2000) focused on researchers themselves. It developed two forward tracking approaches to assess impact. The first of these, termed ‘networks and flows’, mapped ‘networks of researchers and relevant non-academic beneficiaries’, before tracing the impacts of these interactions with an emphasis on qualitative description. Their second approach ('post research tracing') examined the impact of a funded programme of research through the subsequent activities of funded researchers, including their employment outside academe, their consultancy/advisory roles, and the development of further research work. Again this is important. If we are attempting to track the impact of research on the economy and society it needs to be holistic.

4. Measuring impact

4.1 The basic equation

It is probably fair to say that no study has provided a satisfactory monetarised estimate of the total impact, as defined in section 2.2, of research funding at the aggregate level. Even at the simpler level of specific projects, such estimates tend to be lacking. In this section we propose what we believe impact should measure in an ideal world and outline the difficulties in capturing this. We argue that total impact (TI) is the sum of all the net benefits attributable to the research converted into monetary terms *discounted over time and space*:

$$TI = \sum_{i=1}^{I} \sum_{t=0}^{T} \sum_{s=1}^{S} \alpha_{its} B_{its} d_{it} d_{s} \qquad (1)$$

As discussed in section 2.2, research needs to be transformed into innovation, e.g. product, process or policy innovation and α_{its} is the proportion of the innovation which is attributable to the research. B_{its} are the net benefits of the innovation in impact i, period t and spatial location s. This relates to a single piece of research which has I different impacts[4], e.g. revenue, jobs, health and the environment. d_{it}, the time discount factor which is assumed invariant over spatial location.

This approach can be linked to the research payback approach, but instead of plotting the results in a spider plot, they are all combined into one measure. To a large extent equation (1) is also consistent with much of the literature in the econometric tradition, apart from the

[4] I being the upper limit in the summation in (1), the sub-impacts thus combine in determining overall impact.

concept of spatial discounting (d_S). S denotes the number of spatial locations. For UK research these could comprise (i) the UK, (ii) the EU, (iii) developing countries and (iv) non-EU developed countries. If one is interested in determining impact per se then there is arguably little justification for spatial discounting. But if one is seeking to determine the benefits of the public funding of research of UK based institutions, it becomes more relevant. There is little in the literature to guide us on spatial discounting. Arguably GDP related impacts on all countries outside the UK should be discounted relative to UK impact, which is not discounted at all. But being as the UK gives aid to developing countries, these may qualify for a smaller discount factor than, e.g., OECD countries. In addition, it may be that environmental or health benefits should have lower spatial discount rates than GDP.

If more than one firm/university is engaged on research, the net benefit needs to take cognisance of the fact that all of them incur research costs. These firms are then part of the counterfactual as discussed earlier. For example in the pharmaceutical industry, it is sometimes the case that several firms are developing an identical drug and the successful one is the one that wins the patent race (Anand, 2011). In this case the only gains are to the researchers who hold the patent. If the rival researchers are in another country, then there will be GDP impact, but possibly not a health one for the researcher's country. Even if rival drugs are not being developed, close substitutes often exist and are being marketed[5]. The health impact then needs to be evaluated on the therapeutic advantage of the developed drug over the alternatives. Finally, there is a need to avoid double counting, when the social benefits are already partially included in the revenue benefits.

4.2 Problems

The problems involved in calculating TI are considerable and vary across disciplines. With respect to α_{its}, in the sciences where the research has led to a patent then it is reasonable to assume that 100% of the research has led to the patent. There may still be problems if the patent cites other patents or if this is joint research with other parties. In this case the contribution of

[5] For example in 2012 there were approximately 20 beta blockers on the market (Bloom, 2012).

specific researchers will need to be evaluated. But, as emphasised in section 2.1, research is not impact, the patent is not impact. In the case of a commercial product, the research needs to be developed into a marketable product and that then needs to be marketed. Sometimes this development involves further research, e.g. what in the pharmaceutical industry is called translational research, and in many cases this is not done by the academics[6]. If the patent brings with it royalties, and if these royalties are determined in a competitive market, then they are an indication of the research's worth. Similarly if the patents are sold then this is an indication of their discounted value, provided the sale was done under competitive conditions. For the social and managerial sciences, impact is often related to a policy decision. But it is rare that a single piece of research has a decisive influence on policy. Rather policy tends to be based upon a large body of work constituting 'the commons.' This is the key problem in evaluating research impact in the non-sciences and is the reason many are struggled with the REF.

4.3 Measuring net benefits (B_{its})

As discussed in section 3, in principle it is fairly straightforward to obtain an estimate of the benefits using an econometric approach. This can be done for sales, costs, deaths, road accidents, pollution, tourism, etc. In the case of a road accident, we then convert this into a monetary value by putting estimates on (i) the value of human life, (ii) the monetary cost to the authorities, particularly the emergency services, of dealing with the accident and (iii) the congestion costs to other road users. However, as also discussed in section 3, in practice there are often substantial problems in doing this. The data may not exist, or is infeasible to collect. Even if it does exist, extensive data time lags, coupled with the lags in research and transforming research into innovation and then impact, inevitably mean we are evaluating

[6] For example in America out of NIH, the public funding body, funded projects with 'translational' in the title, in the period 2001-2010 just under half, 45% were done outside universities or research institutes and 14% were done by commercial firms (Fishburn, 2013). This represents public funding and it seems likely that academic involvement will be smaller when private funding is involved, although industry academic co-operation is becoming increasingly common (Hudson and Khazragui, 2013).

research done in the somewhat distant past. In principal the problem is less acute for research which results in a new product marketed by a firm. But outsiders to the firm, even possibly the university IPR holders, may still find it impossible to get the data. There may also be problems in estimating the impact net of the counterfactual. If the firm had not introduced that product, then what would have been the alternatives and what would they have been worth?

The situation is further complicated by the need for the economic impact of research to take account of indirect effects such as the multiplier. This is the process by which new jobs generate income which is spent by the recipient employees and local businesses, generating further employment and income. It might be argued that this is not research impact. But it is part of the counterfactual, and as a consequence impact should include the multiplier, as in a report for the UK space industry (UK Space Agency, 2010).

5. REF case studies

5.1 Impact in the REF

The REF is made up of four panels, A,B,C and D, which together cover 36 units of assessment (UoA). These include, e.g., physics, economics and econometrics, education and English language and literature. Each university[7] submitting a to a UoA will need to provide a number of impact case studies which will be evaluated by expert sub-panels. There are 5 sections to the case study: (i) a summary, (ii) a description of the underpinning research, (iii) the references, (iv) the impact and (v) corroborating evidence for this impact. In the REF's generic guidelines, impact is defined as "an effect on, change or benefit to the economy, society, culture, public policy or services, health, the environment or quality of life, beyond academia" (REF, 2011). Examples are given and include effects on, changes or benefits to the activity, attitude, awareness, behaviour, capacity, opportunity, performance, policy, practice, process or understanding of an audience, beneficiary, community, constituency, organisation or individuals. It also emphasises that it includes the reduction or prevention of harm, risk, cost or

[7] Universities will typically make submissions across a wide range of units, although not every department will have made a submission in its own subject areas. Often, e.g. economics departments submit as part of the business and management studies submission.

other negative effects. This is a very wide list, but it specifically excludes impact on research or the advancement of academic knowledge within universities and in general impacts on students, teaching or other activities within the submitting university.

The panel guidelines offer examples of impact which vary slightly, but in practice are again all very wide indeed. For example the Guidelines for Panel B, which relates to the sciences, specify impacts "that have provided benefits to one or more areas of culture, the economy, the environment, health, public policy and services, quality of life, or society, whether locally, regionally, nationally or internationally". These go far beyond simple economic impact. 38 Specific examples are given which include: (i) a spin-out business, (ii) informing policy decisions or changes to legislation, regulations or guidelines, (iii) informing the awareness, attitudes or understanding of the public, (iv) a new drug, treatment or therapy that has been developed, trialled with patients, or adopted, (v) improving the quality of life in a developed or developing country by new products or processes and (vi) changing the management of an environmental risk or hazard. The Guidelines go on to emphasise that all types of impact will be considered equitably in terms of the assessment of the 'reach' and 'significance' achieved during the assessment period and that there is no spatial discounting as in (1). Of course the assessment panels may not implement these Guidelines in this way and there may also be differences in the way different panels approach the task.

5.2 The case studies

During 2010 the REF team ran a pilot exercise to test and develop proposals for assessing the impact of research in the REF[8]. This involved 29 UK higher education institutions submitting evidence of impact which was assessed by pilot expert panels in the five REF UoA shown in Table 1. The case studies, which were rated as excellent, reflect perceptions of what both academics and the expert panels perceive as impact. We discuss these in order of subjects or UoAs and hence the narrative is somewhat random in terms of impact themes. Nonetheless a systematic typology does begin to emerge with the science subjects focusing on revenue and

[8] See http://www.ref.ac.uk/background/pilot/

context specific impact relating to some product innovation. But as we move away from the sciences, the types of impact focus less on revenue and become more diverse. This typology is also in evidence with respect to the identity of ‘the entrepreneur’ or innovation partner. In the sciences this is often a firm, sometimes a multinational and sometimes a spinout firm. It is also apparent that the case studies are narratives, rather than an assemblage of quantified facts and there is no attempt to evaluate a measure of impact as in equation (1) which discounts over time and space. Indeed there are no attempts at all to put an overall monetary figure on the value of the impact or to contrast that with the research costs.

The clinical medicine studies often involve patents and the benefits revolve around revenue and health. This includes Imperial College’s Thiakis, a spin-out company which has been sold twice, ending up with Pfizer. The underlying research pioneered the use of gut hormones as natural appetite regulators. One particular analogue was developed by Thiakis, and was then evaluated by Pfizer as a potential therapy for obesity[9]. The second Imperial College case study involving the treatment for rheumatoid arthritis (RA), does not seem to have directly financially benefitted Imperial from IPR revenues, but amongst the funders of this research are listed the pharma firms GSK and Wyeth. The remaining clinical medicine case studies do not relate to the development of new drugs per se, but there are still benefits to the universities and the UK, and they illustrate the diverse aims behind the public funding of university research. Cardiff’s research has facilitated the identification and characterisation of a series of genes for major inherited disorders. New genetic tests which allow earlier and more accurate diagnosis, are now available in the UK and Europe. In North America, Myriad Genetics markets the Colaris AP® testing kit which uses MYH gene technology, generating over £100,000 in royalty income for Cardiff University. At Exeter and Plymouth research again related to diabetes, whilst Oxford developed simple clinical risk scores to identify patients with a high-risk of a

[9] However, there are reports that in 2012 Pfizer has ceased to develop this, with its future uncertain http://www.bioworld.com/content/imperial-innovations-regaining-thiakis-obesity-drug-pfizer accessed 9.09.2013

major stroke. Finally, at Glasgow a study researched the evidence that smoke-free legislation has a significant impact on heart disease.

The physics case studies tend to revolve around spin-out companies and the benefits revolve around revenue, employment and context specific benefits such as health and security. But in many cases one feels there is more to tell. Take, e.g. Durham's research on vapour growth of semiconductor compounds which led to a patented breakthrough with uses in energy sensitive X-ray detectors and thermal imaging. The process was commercialised by a spin-out company, Kromek Ltd., which employs over 60 people. The company has incorporated this detector technology into medical imaging products and security systems for screening liquids and gels at airports, helping to reduce current restrictions on carry-on baggage and duty free goods. This application won the $400,000 prize in the international Global Security Challenge, and the company currently has a $4M contract to provide large area thermal substrates for the US Defense Threat Reduction Agency. There must also be other health and security benefits, but the case study fails to develop these, possibly because of space constraints.

The impact described in the other UoAs revolve much less around revenue. In ESES two involve patents, one is linked to improved weather forecasting, another one claims the expertise gained from their research facilitates their consultancy activities for the oil industry. The benefits of the latter are real, but it is a little difficult to specifically tie them to any specific research. Only one of the ELL case studies features patent or spin-out company revenue. The others tend to focus on public engagement impact, although the Kingston one claims core economic benefits in enhancing the quality of a visitor attraction, and hence visitor numbers, and the UCL one reports licensing income. The impact of the SWSP case studies are focused more on policy, although cost savings are also emphasised. But surprisingly perhaps there is little on public engagement. One problem with the SWSP studies is that this research is part of a substantial body of research which will be impacting on the different decision makers. Yet this is seldom emphasised.

Insert Table 1 about here.

6. Conclusions

Measuring research impact is not an easy task and there is a risk that in focusing on what we can measure, we will ignore what we cannot. But it is necessary for two reasons. Firstly, at a time of economic hardship, governments are requiring all forms of expenditure, including research expenditure to be justified[10]. But possibly even more important, unless we can measure impact, then it is difficult to maximise that impact and also to allocate public money optimally. The case studies emphasise a relatively simplistic approach to impact in the context of telling a story. The science ones tend to focus on revenue and numbers employed from spin-out companies and licensing, vague references to firms and institutions that have benefitted from the research and generally unquantified health, environment or other benefits. They do not attempt to measure the net impact of the research, with the contribution of impact partners taken out. In addition the case studies seem to imply that if they had not done the research then it would not have been done at all, and hence claim all the benefits. This may not be too serious if one is attempting to get some rough perception of a university's research impact. But if one is trying to make the case to funders that research pays, we need something more sophisticated, which discounts both spatially and over time, develops a counterfactual and nets out the research impact from that of the impact partners.

To get an overall picture, the funders of research themselves need to track each project over a prolonged period of at least a decade and preferably longer, where the impacts in terms of revenue, patents, output, employment, health, the environment and everything else, including the contribution to the commons need to be recorded under headings which allow spatial and time discounting. At the moment this is not being done, as research funders also illustrate their impact with 'stories' and these too tend to be success stories. Hence they do not give an idea of the return to total research funding. The next REF may also require such holistic information

[10] Hence de Campos (2010) argues that increasing government investment in research has increased the pressures on the research councils to comprehend the economic and social impact of research, a trend a harsh economic climate is likely to exacerbate. It is also reflected in the emphasis the web pages of the research councils now place on economic impact. For example the EPSRC highlights "the impact our investments are having on the UK economy and on everyday life", accessed 8/09/2013.

from universities and they would be wise to begin this auditing process now. In this case it will have moved a little away from the narrative approach and be based more on actual numerical data on impact. In doing this it would help if HEFCE were to provide monetary conversion factors e.g. the value of human life, injury, congestion, clean rivers, etc. New ways of measuring impact may also be employed. Altmetrics derives such measures generally from online activity such as mentions, downloads, tweets, blog posts, Facebook "likes," bookmarking and other similar evidence of attention (Travis, 2013). These may be most use in supplementing citation counts and journal impact factors, rather than impact as we have been analysing it. But even here some elements of impact such as public engagement and changes in practice related to society may benefit from an altmetrics approach.

The case studies also revealed the important role played by funding in most of the case studies across all the disciplines. In many of these, it involved funding from the research councils, although private funders such as Leverhulme and the Wellcome Trust were also in evidence. In some cases the funding came directly from the innovation partner, who may well have initiated the research. For the sciences, this tended to be industry, although the Cardiff, Glasgow and UEA studies were funded by diverse public sector agencies. In the non-sciences this was often government departments. But at some stage all research needs the involvement of others to convert it into impact. Hence research may not subsequently have a substantial impact because of the lack of involvement of suitable impact partners. Similarly without the involvement of British, or more generally domestic, firms, then the benefits of science based research may well be reaped by multinationals or foreign firms. The impact agenda has been viewed as a form of academic capitalism with academic research a driver of economic prosperity and affluence (Watermeyer, 2014). But this is not happening, at least to its full potential. The quality of UK academic research is widely recognised, this is a strength that can be used to a greater extent to strengthen the British economy. However, at the moment that strength is not being fully exploited (Hudson and Khazragui, 2013). This is something future REFs may also pick up on.

In the light of our analysis, what can we say about some of the fears which have been raised about the REF as discussed, e.g., by Watermeyer (2014)? Firstly, in our analysis we found little evidence for a homogenised and one-dimensional version of impact dominating the REF submissions either in the pilot case studies or the impact case studies we have been involved with and seen in various universities. There are some common themes, often by discipline, with the sciences emphasising revenue and patents, e.g., but impact is multidimensional and each case study tends to have some unique selling point. In terms of it tending to make academics less radical, we would observe that many of the impact case studies outside the social sciences are based on commissioned research, rather than stemming from some fundamental piece of academic research. But there is no reason why academics should become less radical in their other research, unless they fear that this will exclude them from future contracts, which is a thought which would have already been there. However, in this sense the initial idea for the research – arguably the most important and difficult part of research – comes not from the academic but the people commissioning the work. To a limited extent the problems this raises would be reduced if the threshold for the work on which the impact was based was raised from its current 2* level to at least 3*. This would also reduce fears of two types of academics appearing. In terms of academics and universities changing their behaviour, in a sense this is what the REF was designed to do, but in positive ways, not in a game playing sense. The potential for a market in impact academics opening up, as it has with star publishers, is limited because, unlike publications, research impact cannot be sold on the open market. The rules restrict the impact to the university where the research was carried out and given the time lags involved universities are going to have to focus on nurturing home grown impact, which is probably a positive development. Finally the fear that academics will be forced away from their traditional perspective of pursing knowledge for the public good has relatively little foundation, as impact in the current REF has been drawn very widely. It has been designed to allow the academic to demonstrate the influence their work has had on the public good in a very wide sense, including public engagement, which is in itself important (Hudson and Orviska, 2011).

Of course this may change in the future, and indeed we are arguing in this paper that to an extent it should change.

However, in our pursuit of impact, we should not ignore the value of traditional academic research, research for the commons. Academics and universities should always remember that the basis of their reputation, prosperity, and indeed impact, ultimately lies with high quality academic published work. Apart from any other considerations, and there are many, that in itself adds to the prestige of an institution and a country and in attracting students to study in that institution or country it too has ‘economic impact’, albeit one not recognised directly by the REF. The impact agenda should be simply about ensuring that that work efficiently gets transformed into impact to the benefit of the UK, the EU and indeed the world as a whole. Critically too, there must always be a place, and time, for an academic such as Peter Higgs, who discovered the Higgs boson. He has expressed concerns that such was his focus on this research that for some periods he had no papers to report and no apparent impact[11]. Yet the impact of such academics is enormous, and if the emphasis on impact and more generally evaluating academic quality over a limited time span, means that there is no longer a space for a Peter Higgs, or at least a Peter Higgs pursuing a piece of research such as the Higgs boson, it will have been extremely counter-productive.

Finally we agree with Watermeyer (2014) that the emphasis on research impact will not go away. It will change after the current REF as lessons are learned, but it will not go away. The rationale for the case studies has been to allow academics to demonstrate the impact of their research. In this it is subject to substantial limitations as outlined above and of course many academics deplore the whole exercise (Watermeyer, 2014). But from our own perspective, if it makes academics think more about maximising the benefits of their research, then that is a good thing. There are lessons in all this for both academics and universities in other countries.

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Table 1: The HEFCE Pilot Impact Case Studies

Clinical Medicine

University: Main funders	**Case study**	**Gains**	**Comment**
Cardiff: Welsh Assembly	*characterisation of genes*	Health, revenue, public engagement.	No attempt is made to quantify the health benefits, even in terms of people affected.
Exeter & Plymouth: MRC *et al*.	*Therapeutic intervention in patients with neonatal diabetes*	Health.	The new treatment has been adopted internationally such that more than 400 patients worldwide have had their diabetes therapy changed since 2005. But 400 worldwide does not seem that great an impact
Glasgow: NHS Scotland	*Smoke-free legislation and hospitalisations for*	Public engagement	Evaluated the impact of legislation in Scotland.

	Acute Coronary Syndrome		
Imperial College: EU & multinationals	*Anti-TNF: a revolution in the treatment of rheumatoid arthritis*	Revenue, health	Health benefits are not really quantified. Sales of the 3 licensed TNF inhibitors reached $9 billion in 2006.
Imperial College: MRC	*Development of a spin-out company to investigate synthetic oxyntomodulin analogues for obesity therapy*	Revenue, potential health	Spin-out firm sold for approximately $30 million with potential additional payments of $120 million. Potential health benefits, as drugs are still being developed, are discussed with some numbers.
Oxford: MRC	*Reduction of recurrent stroke risk by early intervention*	Revenue, health	Expectation of preventing about 10,000 strokes per year and saving the NHS up to £200 million.

Physics

Cambridge: EPSRC	*Teraview and teraherz imaging*	Revenue (spin-out company), health, security.	Health and security impacts are only cursorily dealt with.
Durham: EPSRC	*A spin-out company, manufacturing large semiconductor crystals for medical and security imaging.*	Revenue (spin-out company), medical, space, security	Non-revenue impacts only cursorily looked at.
Imperial College: Royal Society	*Nanomagnetism and anticounterfeiting*	Revenue, employment (spin-out company), industrial and consumer safety and countering criminal and terrorist activity	Non-revenue impacts only cursorily looked at.
Liverpool John Moores (LJMU)	*Spaceport: a tourist attraction based on astronomy*	Revenue & local tourist impact, public engagement	Difficult to see how research relates to this.
Warwick: Royal Society	*The consumer electronics industry : The Floating Low-energy Ion Gun.*	Revenue	Non-revenue impacts not discussed.

Earth Systems and Environmental Sciences (ESES)

Glasgow: MAFF	*Establishing methods to detect irradiated foods*	Consumer safety	Led to new UK and European standards Little attempt is made to quantify this impact
Leeds: Industry	*Turbidites research group consultancy*	Revenue and help to oil industry	This is an industry funded consultancy group and it is difficult to separate the research component from the consultancy one.
Manchester: NERC, ESRC	*Spin-out for extensive environmental monitoring*	Spin-out company: two products for monitoring water quality in distribution and one for monitoring ground gas. Patents have been applied for and licensed to Siemens	Revenue aspects stressed, although not so much the environmental and QOL benefits. It is not clear which of the research publications feed into this and how.
Stirling: BBSRC,	*Conservation of bumblebees*	Bumblebee preservation, public	Centres around the founding of the Bumblebee Conservation Trust, with

Leverhulme		engagement, small amount of employment	7,000 members.
UEA: MET Office	*Compilation of the CRU Global and Hemisphere Land Area Temperature Record and Future Climate Scenario Analysis.*	Improved climate change scenarios and UK weather forecasting.	Does not discuss potential secondary impacts.

Social Work and Social Policy (SWSP)

Leeds: ESRC	*Evidence-based policy: Applications of methodology.*	Influenced the "evidence based policy movement".	This is essentially work done for the commons filtering through to impact on policy evaluation and as such is difficult to evaluate its contribution.
LSE: EU's DG Employment & Social Affairs	*Financing long-term care*	Better planning for present and future costs and benefits associated with alternative scenarios for social care.	Much of the impact via modelling exercises.
Ulster: ESRC	*The Review of Public Administration in Northern Ireland*	Potential cost savings and The research looked at the origins, implementation and impacts of the review on working conditions in public sector.	One of the few to emphasise that it will always be difficult to establish a direct cause and effect relationship between research conducted and impacts on public policy.
York: ESRC	*Child support research and policy impacts*	public sector cost savings and reduction in personal conflict between estranged parents	Significant impact claimed on separated parents and their relationships.
York: ESRC, Save the Children.	*The impact of research on child well-being*	Improved child well-being and secondary effects such as increased educational attainment	A similar group of researchers to the other York study.

English Language and Literature (ELL)

Cambridge: Not mentioned	*Topography, ecology and culture*	public engagement	Enhanced public awareness of the natural world and issues concerning the destruction of habitat.
Kingston: AHRC	*Henry VIII at Hampton Court Palace*	Tourism revenue, public engagement	Research on Henry VIII's court has been used to enrich the visitor experience at Hampton Court.
Lancaster: Department of Education and skills, ESRC	*Literacy research in informing policy-making and improving public services.*	Linked to changes in public service practices/guidelines	Improved educational attainment among disadvantaged groups
QMUL: British Library, Arts Council	*Public understanding of poetry*	public engagement	Much of the impact is via a BBC Radio 4 show and it is difficult to link research specifically with this.
UCL: ESRC, Leverhulme, Sasakawa Foundation	*Creating educational and commercial access to English language resources.*	public engagement, revenue	Research used to build web resources for grammar teaching and learning, specifically, the *Internet Grammar of English.* Revenue has been generated from the sale of licences

Note: ARC/BBSRC/EPSRC/ESRC/MRC/NERC are all UK research councils